A Summary of Current Program and
Preliminary Report of Progress

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TOBACCO RESEARCH

of the

United States Department of Agriculture
and related work of the
State Agricultural Experiment Stations

This progress report is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on USDA and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of USDA and cooperative research issued during the last year. Current agricultural research findings are also published in the monthly USDA publications, Agricultural Research, and The Farm Index.

UNITED STATES DEPARTMENT OF AGRICULTURE
Washington, D.C.
December 1967

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A copy of any of the reports may be requested from Axel L. Andersen, Executive Secretary, Tobacco Research Advisory Committee, Research Program Development and Evaluation Staff, U. S. Department of Agriculture, Washington, D.C. 20250.

RESEARCH ADVISORY COMMITTEES

The following Research Advisory Committees were established pursuant to Title III of the Research and Marketing Act of 1946:

1. Farm Resources and Facilities
2. Utilization
3. Human Nutrition & Consumer Use
4. Marketing
5. Agricultural Economics
6. Forestry
7. Animal & Animal Products
8. Cotton
9. Grain and Forage Crops
10. Horticultural Crops
11. Oilseed and Peanut Crops
12. Plant Science & Entomology
13. Sugar Crops
14. Tobacco

The source materials used by the advisory committees include organizational unit progress reports and subject matter progress reports. The latter contain information which was first reported in the organizational reports and has been assembled for use by commodity committees. The number prefixes shown below refer to advisory committees listed above.

ORGANIZATIONAL UNIT PROGRESS REPORTS

Agricultural Research Service (ARS)

1 - Agricultural Engineering
1 - Soil & Water Conservation
2 - Utilization -- Eastern
2 - Utilization -- Northern
2 - Utilization -- Southern
2 - Utilization -- Western
3 - Human Nutrition
3 - Consumer & Food Economics
4 - Market Quality
4 - Transportation & Facilities
7 - Animal Husbandry
7 - Animal Disease & Parasite
12 - Crops
12 - Entomology

Economic Research Service (ERS)

1, 5 - Economic Development
4, 5 - Marketing Economics
5 - Farm Production Economics
5 - Economic & Statistical Analysis
5 - Foreign Development & Trade
5 - Foreign Regional Analysis
5 - Natural Resource Economics

6 - Forest Service - Research (FS)

4, 5 - Farmer Cooperative Service (FCS)

4, 5 - Statistical Reporting Service (SRS)

SUBJECT MATTER PROGRESS REPORTS

6 - Forestry (other than Forest Service)
7 - Animal-Poultry & Products Research other than Husbandry, Disease and Parasite
8 - Cotton and Cottonseed
9 - Grain and Forage Crops
10 - Horticultural Crops
11 - Oilseed and Peanut
13 - Sugar Crops
14 - Tobacco

INTRODUCTION

This report deals with research on tobacco. It does not include extensive cross-commodity work, much of which is basic in character, which contributes to the solution of not only tobacco problems, but also to the problems of other commodities. Progress on cross-commodity work is found in the organizational unit reports of the several divisions.

The report covers Farm Research; Consumer and Industrial Use Research; and Marketing and Economic Research. As shown in the table of contents, there is a breakdown of the research program by problem areas.

This report is organized by problem areas which are shown as the major subjects under the three main divisions in the table of contents. For each of the problem areas there is a statement of (1) the Problem, (2) USDA AND COOPERATIVE PROGRAM, (3) PROGRAM OF STATE EXPERIMENT STATIONS, (4) PROGRESS--USDA AND COOPERATIVE PROGRAMS, (5) PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS.

Tobacco research is supported by (1) Federal funds appropriated to the research agencies of the U. S. Department of Agriculture, (2) Federal and State funds appropriated to the ten State Agricultural Experiment Stations and Puerto Rico, and (3) private funds allotted to research carried on in private laboratories or to support of State Station or USDA work.

Research by USDA

Farm Research in the Agricultural Research Service comprises investigations on breeding and genetics, culture, variety evaluation, diseases, insects, and crop harvesting, handling operations and equipment, and curing. It is carried out in the following divisions: Crops, Entomology, and Agricultural Engineering. The work involves 66.5 scientist man-years of scientific effort.

Consumer and Industrial Use Research in the Agricultural Research Service is mainly concerned with the chemistry and biology of tobacco and the smoke therefrom. Much of the research is basic in nature and health oriented but many findings may be of value to industrial problems not related to health. This work is conducted at Eastern Utilization Research and Development Division, Wyndmoor, Pennsylvania, and the University of Kentucky. The work involves 36.8 scientist man-years.

Marketing and Economic Research is done in two services. Marketing research in the Agricultural Research Service deals with the physical and biological aspects of assembly, packaging, transporting, storing, and distribution from the time the product leaves the farm until it reaches the ultimate consumer. Economic research in the Economic Research Service deals with market structure, practices and competition; product quality; margins, costs, and efficiency; economics of farm production; supply and

demand; and outlook and situation. The work reported herein is done by the following divisions: Market Quality Research and Transportation and Facilities Research Divisions in ARS, and the Marketing Economics, Farm Production and Economics, and Economics and Statistical Analysis Divisions in ERS. The tobacco research in the marketing and economic research area involves 11.3 scientist man-years of scientific effort.

Interrelationships Among Department, State and Private Research

A large part of the Department's research is cooperative with the State Experiment Stations. Many Department employees are located at State Stations and use laboratory and office space close to or furnished by the States. Cooperative work is jointly planned, frequently with representatives of producers or industry participating. The nature of cooperation varies with each study. Ordinarily programs are developed so as to fully utilize personnel and other resources of the cooperators, which frequently includes resources contributed by interested producers or industry.

Research is in progress on all domestic tobacco types in the various production areas with especially close cooperative research at 12 agricultural Experiment Stations. Research effort is devoted to breeding and genetics; diseases, insects, nematode and weed control; quality, culture, physiology, harvesting and curing; and to chemical and physiological studies on health-related aspects of tobacco. These studies are being conducted by the Crops Research, Entomology, Market Quality and Eastern Utilization Research and Development Divisions of ARS. Much of the research is conducted through grants or by contract.

Close cooperation is also maintained with private industry including cigarette and cigar manufacturers, chemical companies, and machinery manufacturers. All of the tobacco companies conduct vigorous and diverse programs designed to improve the quality of the product and reduce manufacturing costs. These companies are also investigating new methods for producing "homogenized tobacco leaf" or "sheet tobacco" for cigarettes or cigar binders or wrappers; developing new tobacco varieties; and determining chemical composition of leaf and smoke. The tobacco companies' work depends considerably upon discoveries resulting from fundamental work by public agencies.

Research by chemical companies is concerned with the development of new tobacco flavoring agents, cigarette paper and filters, chemicals for agronomic use, "sheet tobacco" process, and new and improved machinery for manufacturing tobacco products. The Department and other public agencies continue to provide much of the basic data needed to carry out these programs.

The manufacturers of chemicals for disease control and plant growth regulation continue to expand their efforts to produce new products and introduce them into use. The Federal Government assists in this area in the evaluation of new plant growth regulators and their effect on quality.

Basic research done by the Department and States will be utilized by industry and other organizations in their research programs, especially in the further development of improved products and equipment. Industry's cooperation in supporting tobacco research at Federal and State Stations has contributed greatly to its success.

The following results by the Eastern Utilization Research and Development and the Agricultural Engineering Research Divisions, Agricultural Research Service exemplify research accomplishments pertaining to tobacco.

Macromolecules in Cigarette Smoke. In Department studies on the relationship between cigarette smoking and health, an unusual and complex material--a pigment of very high molecular weight--has been isolated from cigarette smoke. The pigment contains iron, chlorogenic acid, at least 18 amino acids, a silicone material, and several alkaloids, including nicotine. The pigment is the first reported instance of the presence in tobacco smoke of nicotine or other alkaloids in a component of high molecular weight. There is evidence that the smoke pigment comes from a pigment in the tobacco leaf.

Cigar Filler Types Characterized. Four types of cigar filler tobaccos--Pensylvania, Columbian, Puerto Rican and Dominican--have been distinguished from each other objectively through analysis of the tobacco smoke by gas chromatography. Each smoke displayed unique--and hence characteristic--patterns on the chromatograms. Easiest to identify this way was Columbian smoke, which also showed the most characteristic flavor and odor. The research was cooperative with the Cigar Manufacturers Association.

Combined Use of Light and Sex Attractants Increases Moth Catches. Blacklight (near ultraviolet) trap catches of tobacco hornworm moths increased significantly when virgin females were placed in the vicinity of the traps in North Carolina experiments. In similar tests with the cabbage looper in California, placement of live virgin female moths in the vicinity of light traps was found to increase collections of male moths from 4 to 95 per trap per night. Similar increases in catch of males were observed when a synthetic sex pheromone replaced the caged virgin females. Further testing of this response by the hornworm moths is being made on the island of St. Croix, V.I., where 240 blacklight traps are in experimental operation to control the insect. Additional work of the same type with the cabbage looper was initiated near Red Rock, Arizona, in late 1966 with the installation of 400 blacklight traps and synthetic sex pheromone added to determine possible control of this pest in 2,000 acres of lettuce.

Mechanized Burley Tobacco Handling. A mechanized method of handling harvested Burley tobacco on portable curing frames has been developed in cooperation with the Kentucky Agricultural Experiment Station. Using a front-mounted tractor loader, steel or wood frames, filled in the field,

are stacked in a clear-span curing structure. The cured tobacco may be removed from the barn while out-of-case, and placed into a steam casing chamber. This allows stripping of the cured leaf and preparation for the early market, regardless of climate conditions. Mechanizing the combined operations of transport between field and barn, housing, and casing have resulted in a 35 percent reduction in man-hour requirements for handling from the time after harvest through casing.

I. FARM RESEARCH

BREEDING AND GENETICS, DISEASES, WEEDS, NEMATOLOGY, QUALITY, CULTURE AND PHYSIOLOGY, AND AIR POLLUTION

Crops Research Division, ARS

Problem. World consumption of tobacco continues to increase along with rising income and population growth, and our domestic use of tobacco and its products is no exception to this trend. At the same time, our exports, as a percentage of the world market, show a considerable decline. The problem is to produce tobacco of the high quality standard needed to meet changing use requirements of domestic and world markets and at the same time keep costs of production on a profitable and competitive level. To meet this objective, a continuous fund of new information is required which will enable the farmer to combat pests, cultivate, harvest, and cure good yields of quality leaf at minimum cost. Concern over smoking and health has added new dimensions to the problems of tobacco production and use.

USDA AND COOPERATIVE PROGRAM

The Department has a continuous long-range program of basic and applied research extending from seeding to cured leaf, involving the genetics physiology, and biochemistry of the tobacco plant, agronomic practices, and disease control.

Research work is in progress on all domestic tobacco types in the various production areas with close cooperation of the Agricultural Experiment Stations in the following States: Connecticut, Florida, Georgia, Kentucky, Maryland, North Carolina, Pennsylvania, South Carolina, Tennessee, Virginia, West Virginia, Wisconsin, and the Commonwealth of Puerto Rico. Cooperation with industry is as follows: Brown & Williamson Tobacco Corporation; Liggett & Myers Tobacco Company; Phillip Morris, Inc.; P. Lorillard Company; R. J. Reynolds Tobacco Company; The American Tobacco Company; The Imperial Tobacco Company of Great Britain and Ireland; Bayuk Cigars, Inc.; General Cigar Company, Inc.; Consolidated Cigar Corporation; and Cigar Manufacturers Association of America, Inc.

Extramural research is in progress with the Agricultural Experiment Stations in Florida, North Carolina, and Kentucky. This research involves a contract at Quincy, Florida, for field evaluation of blue mold resistance; two cooperative agreements and a contract at Raleigh, North Carolina, to study disease interactions including the major tobacco pathogens and their influence upon leaf composition and to screen for chemicals to

control soilborne diseases without causing harmful residues; and nine contracts at Lexington, Kentucky, to study the genetics of and metabolic processes involved in biosynthesis, translocation, and storage of sterols, phenols, and nitrogenous compounds such as secondary amines and to study the influence of selected agronomic practices and chemical treatments on these compounds.

The Federal intramural scientific effort devoted to this research consists of 41.3 scientist man-years. Of this number 8 are devoted to breeding and genetics, 8 to diseases, 13 to quality and variety evaluation, 12 to culture and physiology, 0.1 to weed control and 0.2 to nematode control.

The Federal extramural scientific effort consists of 11.4 scientist man-years devoted in the following research areas: 3 in breeding and genetics, 2.4 in diseases and their effect on plant chemistry, 3 in quality, and 3 in physiology and culture.

PROGRAM OF STATE EXPERIMENT STATIONS

The research effort of the State experiment stations in this area totals 63.7 scientist man-years.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Breeding and Genetics

1. New variety and new breeding lines of flue-cured tobacco. SC 66, resistant to black shank, Granville wilt, fusarium wilt, and the common species of root knot nematode, was released jointly with the South Carolina Agricultural Experiment Station. It met the rigid standards for variety release established by a five State Tobacco Variety Advisory Committee, and offers to growers a multiple disease-resistant, high yielding tobacco with desirable physical and chemical characteristics.

Breeding line NC 2514, released to plant breeders jointly with the North Carolina Agricultural Experiment Station, combines resistance to six major diseases (black shank, Granville wilt, fusarium wilt, root knot, black root rot, and tolerance to brown spot) with a number of highly desirable agronomic features.

2. Blue mold resistance in cigar-wrapper tobacco. Breeding line Fla. 513, developed under contract with the Florida Agricultural Experiment Station, was released to plant breeders. Its high resistance to blue mold, while

diluted in F_1 hybrids, is adequate for use in shade-grown tobacco. Thus, a nonchemical means of commercial blue mold control in this high value crop is available for the first time.

3. Chemical constituents of F_1 hybrids in flue-cured tobaccos. Tests conducted to compare F_1 hybrids with their parents show, in general, that the F_1 values for nicotine, water soluble acids, total soluble nitrogen, petroleum ether extract, and nonvolatile acids were equal to the midparent values. Most of the F_1 hybrids were lower in total nitrogen and amino nitrogen, but higher in reducing sugars than the parental averages. The chemical constituents that deviated significantly from the average of the midparents were those generally associated with increased maturity. Most of the genetic variance was associated with additive gene action.

4. Combining ability in flue-cured tobacco variances. General combining ability was the most common type of genetic variance found in three studies at Oxford, North Carolina. Significant differences occurred among parents and their hybrids for yield, acre value, and price per cwt. A comparison of the average of all parents with average of all F_1 hybrids showed that the hybrids had greater yield and acre value but essentially the same price per 100 pounds. NC 75, NC 2512, and McNair 12 were good combiners and White Stem Orinoco, Dixie Bright 102, and Beinhart 1000-2 were poor combiners.

5. Pattern of alkaloid buildup in flue-cured tobacco varieties. When averaged over all varieties, the data indicated a strong linear trend toward increased alkaloid content of growing leaf as the season progressed from 35 days after transplanting. However, patterns of buildup differed among the 13 varieties tested. In general, the green leaf results were highly correlated with final amounts of alkaloids in cured leaf.

6. Response of flue-cured tobacco varieties and Nicotiana species to lesion nematodes Pratylenchus spp. Yield depressions due to inoculation, in percent of the uninoculated controls, were as follows: Hicks, 9.0 percent; Virginia Gold, 4.8 percent; DB 101, 4.5 percent; and NC 95, 1.0 percent. Root injury and stunting were connected with reduced yields. The quality of cured leaf was not significantly effected by nematode inoculation.

Among 30 Nicotianae species inoculated with root lesion nematode, some were severely stunted and others were stimulated. Cause of the stimulated growth is not known but the data suggest production of a growth promoting

substance. Range in growth differences among the Nicotiana species was wide and nearly all of them appeared to be less affected by lestion nematodes than the N. tabacum entry in the test.

7. Burley hybrids were early and some outyield the parents. The F_1's were somewhat earlier than their later maturing parent and some outyielded the higher yielding parent. The hybrid showing most promise was MS Burley 21 x Ky. 10. Three black shank resistant hybrids, MS Burley 21 x L8, MS Burley 37 x L8, and MS Ky 12 x L8 compared favorably to Burley 37 in yielding ability and quality.

8. Genetic variation for chemical content. Ranges of 0.1-0.25, 0.14-1.48 and 0.17-4.93 percent, respectively, were determined in content of sterols, nitrates, and alkaloids in air-cured leaf from 152 tobacco introductions and 7 locally adapted varieties in contract research at the Kentucky Agricultural Experiment Station. Intramural research showed phenol content ranged from 0.52 to 2.61 percent. Burleys were significantly lower in phenol content than green tobaccos similarly cultured and air cured. Genetic diversity of a quantitative nature for polyphenols was detected and chlorogenic acid content of seedlings and mature plants was found to be correlated.

9. Multiple disease-resistant cigar tobacco. Incorporation of resistance to wildfire, mosaic, and black root rot has been accomplished in cigar filler tobaccos in Pennsylvania. Line Bel. 60-19 was best over all with a yield potential equal to Pennbel 69, and better maturity in its top leaves in an unfavorable growing season.

10. Reaction of tobacco varieties to frog-eye and brown spot. Among 10 varieties tested from three different types of tobacco for resistance to the above diseases, cigar variety Pennbel 69 was most resistant to frog-eye followed by flue-cured NC 2326 and Burley 21. Flue-cured varieties Coker 187, Hicks and Coker 298 were most susceptible. All varieties were susceptible to brown spot. However, flue-cured PD 121 and Pennbel 69 showed less chlorosis at infection sites than other varieties.

11. Use of monosomics in hybridization of Nicotiana species. A disease-resistant species, N. langsdorffii, was crossed with three varieties of normal tobacco and 18 monosomics having one less than the diploid number of chromosomes. Crosses involving the normal varieties resulted in 3,839 inviable seeds, whereas crosses made with monosomic tobaccos produced viable hybrids.

12. Preservation and propogation of Nicotiana species. Special techniques have been developed at Beltsville, Maryland, for growing plants and producing and germinating the seed of 61 Nicotiana species. These species are a reservoir of germ plasm for improvement of cultivated tobacco.

13. Susceptibility to ozone of flue-cured varieties. Twenty-three flue-cured varieties were exposed to three ozone concentrations ranging from .12 to .36 ppm at Beltsville, Maryland. Experiments with plants in small pots, exposed in large numbers, show varietal differences at .10 and .15 ppm. Varieties Coker 298, White Gold (Canadian), and Speight G-7 were the most susceptible to ozone. Reams 64, McNair 30, and NC 2512 displayed the highest level of ozone tolerance.

B. Diseases

1. Studies with pathogens causing brown spot and frog-eye diseases. Histological studies on green tobacco leaves conducted at Beltsville, Maryland, indicate that Alternaria tenuis (causal organism of brown spot) mycelium was found only in the necrotic areas. Cercospora nicotianae (causal organism or frog-eye) mycelium was found in tissue surrounding spots, extending as far out into the leaf as the chlorosis.

Best infection with C. nicotianae was obtained when suspensions containing 750,000 spores per ml. and mycelia grown on V-8 juice agar were sprayed on plants and the plants kept in a mist chamber at about 28°C for five days after inoculation.

Best infection with A. tenuis occurred at Oxford, North Carolina, and Beltsville, Maryland, when a suspension containing 20,000 spores per ml in pH 6.3, 0.01M phosphate buffer with 0.1M glucose was sprayed on plants and the plants were kept in constant mist for three days followed by five days of nightly mist and daily dryness. Day temperatures were 28°C, night temperatures, 21°C. Four-month-old plants were more susceptible to A. tenuis than two-month-old plants.

2. Sprays for control of tobacco brown spot increase yields. Brown spot failed to develop on nontreated checks, therefore, no information was obtained on control of the disease. However, plots involving all treatments produced higher yields than the nontreated controls. The increases over untreated checks were: Maneb (manganese ethylene bisdithiocarbamate), 105 lbs.; Dyrene (2,4-dichloro-6-0-chloroanilini-s-triazine), 244 lbs.; MH-30 (maleic hydrazide), 375 lbs.; combination MH-30 with Dyrene, 642 lbs.; combination MH-30 with Maneb, 465 lbs. per acre.

3. Epidemiology of the brown spot disease on flue-cured tobacco. Infection on the lower leaves became apparent in mid-July at Oxford, North Carolina. Thereafter, the total number of spores trapped per 24-hour period was greatest following 12 to 14 hours of high humidity (at night) or at least 0.1 inch of rain. Spore release occurred between 10:00 a.m. and noon each day. Infection on surrounding tobacco plants was greatest from five to seven days following a period of rain and low temperature (70-75°F).

4. Proteolytic enzymes in the brown spot disease. The incitant (Alternaria tenuis Nees.) produced a protease enzyme(s) in vitro on various protein substrates. Increased in vivo protease activity was detected in necrotic and halo tissue over adjacent green tissue in naturally infected, field grown, and in artificially inoculated greenhouse grown plants at Oxford, North Carolina.

5. Black shank control by crop rotation. In work conducted at Tifton, Georgia, single cycles of 4-year and 5-year crop rotations with Bahiagrass sod eliminated infestations from two fields where the disease had been very severe. A single cycle of a 3-year rotation consisting of rye, bare fallow, and tobacco completely eliminated black shank.

6. Steroid physiology of Pythium and Phytophthora. At Lexington, Kentucky, Phytophthora parasitica var. nicotianae grew poorly on synthetic triglycerides or fats from which the sterols and phospholipids had been removed. Under highly aerobic conditions, this fungus grew well when cholesterol was added to a glucose or triolein medium. The specific effect of cholesterol on sexual reproduction of Pythium periplocum was reversed by antifungal polyene antibiotics, which are believed to act by interference with a membrane function of sterols. A species of Pythium and one of Phytophthora were unable to incorporate acetate into digitonin-preciptiable sterols, unlike species from closely related families.

7. Physiological studies on bacterial wilt of tobacco. An agglutination factor can be isolated from cuttings of tobacco plants that have been made resistant to bacterial wilt by previously inoculating them with an avirulent culture of the organism. The same agglutination factor has been isolated from resistant varieties and the amount of the agglutination may be related to levels of resistance. The factor is found in highest concentration in stems, petioles, and leaves, but can also be detected in the root system.

8. Relative humidity requirements for development of anthracnose. The severity of symptoms is influenced by humidity both before and after inoculation. Without a pre-inoculation period of high humidity, a minimum of 24 hours of high relative humidity is required after inoculation for infection and disease development. Increasing beyond 24 hours, the period of high relative humidity markedly increases the severity of symptoms. Most susceptible plants are killed if high relative humidity is maintained for 96 hours or longer. High relative humidity for 8 hours prior to inoculation increased severity of the disease.

9. Rhizoctonia solani root rot of tobacco. Studies at Beltsville, Maryland, have shown that three strains of R. solani caused severe rotting on roots of Burley 21 and Turkish tobacco (Xanthi), while strain No. 3 caused heavy rotting on Maryland type (Catterton) tobacco. Young seedlings of flue-cured type (Hicks) appeared to be the most resistant of all three strains of R. solani.

10. Control of blue mold on tobacco plants grown under plastic. Experiments conducted at Tifton, Georgia, indicated that blue mold was more effectively and easily controlled in plastic covered seedbeds with benzol vapors than with conventional sprays and dusts.

11. Disease complexes in flue-cured tobacco. In contract research at the North Carolina Agricultural Experiment Station, galls caused by root knot nematode (Meloidogyne incognita var. acrita) were found to be readily colonized by pathogenic fungi and bacteria. Substances produced in root knot galls and translocated into the stalk promoted growth of such pathogens as Pseudemonas solanacearum, Phytophthora parasitica var. nicotianae and Fusarium oxysporum var. nicotianae. Xanthi variety Turkish tobacco plants infested with root knot nematodes became necrotic and died when inoculated with the cucumber mosaic virus. Reproduction of the root knot nematode was greatly enhanced in root tissue of plants infested with virus pathogens.

12. Chemical control of diseases caused by soil-borne organisms. Chemical soil treatments reduced significantly the incidence of black shank and increased value per acre with both moderately resistant and susceptible varieties in research under cooperative agreement with the North Carolina Agricultural Experiment Station. However, practical control was not obtained where a susceptible variety was used alone. Chemical soil treatment with Telone PBC (dichoropropenes) reduced the incidence of Granville wilt and increased value per acre in susceptible and resistant varieties.

C. Weeds

Control of Annual Weeds in Tobacco. A mixture of pebulate and benefin provided good weed control, increased the tobacco yield, and increased the net value of the crop per unit of land when applied by any one of several placement techniques in tests in Georgia.

D. Nematology

Sixteen nematocidal compounds were evaluated at Tifton, Georgia, for root-knot nematode control on tobacco. The best overall performance was given by seven commercially available nematocides and two experimental materials. A chlorinated organic sulfur gave a yield increase of 694 pounds of cured leaf - the highest yield increase. In another study, a soil fumigation-corn rotation program utilizing a commercial halogenated hydrocarbon appears economically feasible for the production of corn and tobacco. This material, which is phytotoxic as a preplant treatment to tobacco, can be safely applied to corn, increasing corn yields enough to pay for the cost of chemical application, yet provides effective root-knot control for the subsequent crop of tobacco the following year.

E. Quality

1. Influence of ripeness and yellowing time on chemical and physical properties of flue-cured tobacco. Best colors were produced when normal to slow yellowing was used on one-week-before-ripe harvests at Oxford, North Carolina. More advanced ripening produced flat dull colors. Within the same harvests, sugars and starch were reduced with the longer yellowing periods. Smoking panel tests indicated that more desirable aromas were found in tobaccos harvested in the early stages of ripeness and cured slowly.

2. Chemical changes during growth, senescence, and curing of flue-cured tobacco. At all stages of growth, sugar content was highest in leaves from the middle of the stalk, and lowest in leaves from the bottom and top stalk positions. The concentration of starch was low when the sugar content was hight and vice versa. Ripe leaves at the time of harvest were very low in sugar but very high in starch. During curing 90 percent of the starch was hydrolyzed to sugars. Nicotine content was high in older leaves, low in younger leaves and did not change during curing. Total nitrogen content was high in young leaves and low in old leaves. As the leaf aged, the starch and nicotine content increased, but total nitrogen and reducing sugars decreased.

3. Changes in fatty acid composition during growth of tobacco plants. In Catterton tobacco plants, five major fatty acids--C-18:3, C-18:2, C-18:1, C-18:0, and C-16:0--were determined as methyl esters. Saturation

of the fatty acids increased with age of tissue. Linolate was predominant in flowers and increased from 37 to 70 percent of total fatty acids in seeds during their development. Linolate was also predominant in young leaves and as they grew older increased from 30 to 60 percent of the total fatty acids present.

4. Nitrogen, amino acids, and polyphenols in tobacco. Levels of scopoletin and scopolin were higher in the tumorous tissue of 2N hybrid (N. glauca x N. langsdorffii) than in either parent. Much higher contents of phenylalanine and tyrosine were found in new tumors than in leaf tissues or nodal meristems.

In normal Nicotiana plants, the phenolic content varied with cultural practices, curing methods, and species. A higher phenolic content was associated with a higher rate of nitrogen fertilization in some varieties. The amino acid composition of Nicotiana samples appeared to affect the level of certain phenolics. Tumorous Nicotiana hybrids and Connecticut broadleaf tobacco plants were fed with C^{14} labeled phenolalanine and tyrosine. Results show that phenylalanine is more efficiently utilized than tyrosine in the formation of various phenolic compounds.

5. Phenols in certain parts of the tobacco plant. Chlorogenic acid and two unknown major polyphenols were present in inhibited buds of tobacco while scopolin, chlorogenic acid, and two polyphenols related to the unknown compounds in inhibited buds were the major phenolic constituents found in growing apex tissue. Further studies of the unknown polyphenols suggest them to be phenolic glycosides of caffeic acid instead of the usual caffeic acid esters found in tobacco leaf.

Rapidly growing friable clones of stem pitch contained greater amounts of phenols than slower growing compact clones. The compact clones, however, contained significantly more total phenols than uncultured stem pith. Chlorogenic acid was the principal phenol present in uncultured stem pith and scopolin was the principal phenol in a two-week culture.

6. Sterols in tobacco and their relationship to chemical treatments. Results from contract research with the Kentucky Agricultural Experiment Station showed sterol content of burley tobacco to be lower than flue-cured. In tobacco treated with Penar (dimethyldodecylamine acetate), at the rate of 200 mg (100 mg twice), there was a significant increase of sterols as compared to that treated with 100 mg. Greenhouse grown Burley 21 tobacco leaves treated with 2,4-D contained less sterols per gram of dry lamina than nontreated leaves. Sterols present are stigmasterol, B-sitosterol, campesterol, and possibly chloresterol.

7. Absorption and translocation of Pb-210 in tobacco plants. Pb-210 in equilibrium with Po-210 applied to the soil was readily absorbed through tobacco roots and translocated to areas of new growth. Similarly, Pb-210 supplied to stems was concentrated in growing tissue. Once in leaf tissue, Pb-210 was not translocated further. Leaves which developed later were free of radioelements.

8. Kinetics of DNA synthesis and turnover in topped and non-topped plants. The rate of DNA synthesis in topped and non-topped plants was compared by using tritiated H^3 thymidine and C^{14} labeled thymidine in research conducted at Beltsville, Maryland. The ratio of H^3 incorporation into buds of topped plants vs. C^{14} non-topped plants showed that the activation of DNA synthesis was started within 4 hours and that the incorporation of H^3 into buds of topped plants was linear between 4 and 24 hours.

9. Distribution and characterization of IAA oxidizing enzymes in tobacco leaf. Enzymatic activity in tobacco leaf tissues, measured by amount of IAA oxidized, decreased as age of leaves increased. Activity was greatest in youngest leaves, and had ceased in fully expanded leaves. Fractionization of leaf tissues by ammonium sulfate precipitation and gel filtration yielded three protein fractions with peroxidase activity. While all three protein fractions catalyzed the oxidation of IAA in the presence of $MnCl_2$ and 2.4 dichorophenol, they differed in pH maxima.

F. Culture and Physiology

1. 1966 Regional Tobacco Sucker Control Test. Fatty acid derivatives, methyl caprate, methyl pelargonate, and a mixture of octanol and decanol were nearly as effective as two maleic hydrazide derivatives. The fatty alcohol mixture octanol and decanol was most effective of any contact agent in controlling suckers on burley tobacco and caused no visible leaf injury. The fatty alcohol, decanol (C-10) was equally effective on all types of tobacco. Proper formulation of contact agents with surfactants is critical in their use to control tobacco suckers without plant injury.

2. Time lapse action of contact and systemic sucker control agents. Young meristems were killed by contact chemicals before any phytotoxicity was observed in the surrounding older tissues. The faster the penetration, the more effective the compound was as a contact sucker control agent. Dessication of young tissues occurred within 5 minutes after the chemical was applied. During the first 12 hours after application, systemic MH-30 stimulated growth of suckers. Cell elongation occurred in the direction of apical growth, involving primarily vascular and mesophyll tissues. Marginal growth was completely inhibited by MH-30, resulting in formation of typical narrow leaves.

3. The effect of light on growth of suckers. Under complete darkness, suckers developed but leaves failed to expand normally. Various day lengths, including continuous light, did not affect sucker growth.

4. Various cultural practices using commercially available sucker controlling agents. Penar and MH-30 used separately on the same plants gave good and sustained sucker control in North Carolina. Penar was applied at an early flower stage and MH-30 was applied two weeks later to control secondary suckers. Where Penar was used as the second application, control was not as effective. A tank mix of MH-30 and Penar at one-half manufacturers' recommendation applied at topping gave good control for a period of three weeks.

5. Effect of sucker control upon cured leaf. Yields increased with improved sucker control irrespective of control method. However, chemical sucker control tended to result in higher yields than control by handsuckering. Also, chemical sucker control decreased percent nicotine, percent total volatile bases, percent ash, specific volume and color of cured leaf as compared with handsuckering. Color changes of chemically suckered tobacco generally resulted in lower official grades in comparison with handsuckered leaf.

6. Chemically topping tobacco. When applied at the proper stage of growth (early button), contact agents inhibit the development of tobacco flower buds as well as suckers. The fatty alcohols, especially decanol, have shown most promise among the chemicals tested.

7. Influence of plant spacings and topping levels on three varieties of flue-cured tobacco. Spacing tobacco plants 14 inches in the row at Tifton, Georgia, increased the average yield of cured leaf only slightly over 18- and 22-inch spacings. Price per cwt increased slightly with the wider spacing and the 15-leaf topping level. The total percentage of best grades increased with the wider spacing and decreased with the higher topping level (21 leaves per plant). Tobacco company representatives selected tobacco from the wider spacing and lower topping over the higher topping and closer spacing treatments. Analytical determinations showed a marked increase in total alkaloids and nicotine with the lower topping levels on all varieties and plant spacings.

8. Fertilization by plant population. Experiments conducted at Tifton, Georgia, show that increasing the rate of 4-8-12 fertilizer from 0.20 to 0.25 and 0.30 pound per plant on two plant populations (7,000 and 9,000 plants per acre) increased the yield of flue-cured tobacco about 100

pounds on the lower plant population and about 200 pounds on the higher population, but generally decreased the price index from one to two dollars per cwt. The higher fertilizer rates also delayed ripening and harvesting. The percentage of total nitrogen and total alkaloids of the cured leaf tended to be higher in tobacco from the higher plant population when the fertilizer rates were constant.

9. Time and method of fertilizer application of flue-cured tobacco. Increasing the rate of preplant fertilizer (4-8-12) at Tifton, Georgia, from zero to 1,500 pounds per acre, in 500-pound increments, resulted in progressive increases in yield, price per cwt, and acre values through the 1,000 pound preplanting rate. All treatments received a total of 1,500 pounds of 4-8-12 per acre. Plants receiving 1,500 pounds of preplanting fertilizer suffered from fertilizer injury, but the yield and acre value of the tobacco still exceeded the zero preplanting (all side dressing) rate by 165 pounds and $140 per acre. Broadcast application of preplanting fertilizer failed to produce crop returns equal to those from tobacco fertilized with an equivalent amount in row application. Increasing the rate of preplanting fertilizer hastened the rate of maturity and increased the yield of best smoking grades of cured leaf.

10. The effect of supplemental nitrogen fertilization on the yield and quality of burley tobacco following leguminous and non-leguminous cover crops. Where vetch was the cover crop, the yield of tobacco at Greeneville, Tennessee, was only about 200 pounds higher per acre with 300 pounds of nitrogen than with no nitrogen, whereas 300 pounds of nitrogen gave a yield increase of about 600 pounds of tobacco over no nitrogen after rye. Both yield and grades of tobacco were exceedingly low where no nitrogen was applied after rye. In general, grades improved with each increment of nitrogen added up to 225 pounds after rye but were progressively poorer with each increment of nitrogen added after vetch.

11. Nitrogen nutrition and susceptibility of tobacco leaves to ozone. Ozone fumigation of Maryland variety Catterton at .18 ppm and .36 ppm caused more damage to plants grown at an optimum nitrogen level (160 mg N/liter) than to plants grown at deficiency (15 mg N/liter) or luxury (800 mg N/liter) nitrogen rates. Injury was more extensive to all plants when administered in a short dose at .36 ppm than when given at .18 ppm for twice the time. Ozone damage was more severe on leaves with total nitrogen levels between 0.5 and 4.5 percent.

12. Oxalate metabolism in tobacco and its relation to calcium nutrition. Plants grown at 24°C at Lexington, Kentucky, showed no calcium deficiency, but certain varieties developed severe calcium deficiency symptoms when grown at 30°C. Temperature also showed a striking effect on the level of enzyme activity involved with oxalate metabolism. Glycolate oxidase and glyoxylate oxidase are much more active at higher temperatures, while the reductases are less active at the same temperature. Both situations lead to the accumulation of oxalic acid and thus make calcium less available to plants at higher temperatures.

13. Environmental control of flowering of tobacco. All varieties and lines of burley flowered earliest and developed fewest leaves when grown under short (about 8 hours) days and moderately cool (about 20°C) temperatures. Increasing photoperiod and/or temperature during growth of burley plants resulted in more rapid growth, delayed flowering, and the development of more leaves per plant.

14. Concentration of amino acids in tobacco from early growth until bud stage. Leaves of four varieties of burley tobacco were sampled, beginning 17 days after seeding, three times a week for 4 weeks and then at weekly intervals for 8 weeks. During growth the concentration of amino acids fluctuated widely and rapidly. The build up and disappearance during growth was similar in the four varieties, but frequently not at the same time. Total amino acids were higher in L8 and lower in Iso 2 as compared to either Burley 21 or Ky 12. Glycine and proline were more variable than the other amino acids and reached higher concentrations in L8 than in the other varieties. The concentration of most of the amino acids was higher in the later samples compared with the earlier ones.

15. Levels of amino acids in burley tobacco during the curing process. In initial phases of curing there were large increases in amino acids and then a decreasing trend starting first with the bottom leaves and progressing up the plant to the top leaves. The concentration of most of the amino acids continued to decrease after the leaf had turned brown and dried but the net gain or loss was small compared to the changes during early curing. The major protease activity occurs during early stages of curing, whereas amino acid oxidases probably function throughout most of the curing process.

16. Nitrogen nutrition and plant development. The total nitrogen content of leaves and stalks of burley tobacco follows the same trends as the nitrate-nitrogen levels in the leaves and stalks. Treatments which increased plant growth, with or without irrigation, increased the relative nitrogen concentrations in both leaves and stalks at the final harvest. This is the reverse of the trend in the sugar levels in the leaves and stalks.

17. Chemical weed control in field production of flue-cured tobacco. The application of a mixture of pebulate (S-propyl butylethylthiocarbamate) at 2 pounds plus benefin (N-butyl-N-ethyl-2,6-dinitro-dipropyl-p-toluidine) at 1 pound per acre, incorporated in the soil with a power-driven rotary hoe, and benefin alone at 1 pound per acre resulted in over 90 percent weed control with the mixture giving the best results at Tifton, Georgia. Pebulate alone and applied using both soil mixed and subsurface methods resulted in beteeen 80 and 90 percent weed control. Vernolate (S-propyl dipropylthiocarbamate) gave good weed control but caused some injury to tobacco plants. Pebulate was also effective against nutsedge. No herbicide, except diphenamid (N,N-dimethyl-2,2-diphenylacetamide), reduced the yield and acre value of the cured tobacco. The herbicide pebulate increased yields and acre values regardless of whether it was incorporated or subsurface applied with sweeps. Benefin, alone and in combination with pebulate, increased yields and acre values of the tobacco. The levels of total nitrogen and total alkaloids were higher and the content of reducing sugar slightly lower in cured tobacco from the herbicide treated plots.

G. Air Pollution

1. Nitrogen nutrition and susceptibility of tobacco leaves to ozone. Ozone fumigations of Maryland variety Catterton at .18 ppm and .36 ppm caused more damage to plants grown at an optimum nitrogen level (160 mg N/1) than to plants grown at deficiency (15 mg N/1) or luxury (800 mg N/1) nitrogen rates. Injury was increased when ozone was administered in a short dose at .36 ppm than when given at .18 ppm for twice the time.

2. Susceptibility to Ozone of Flue-cured Varieties. Twenty-three flue-cured varieties were exposed to 3 ozone concentrations, ranging from .12 to .36 ppm. Varieties Coker 298, White Gold, and Speight G-7 were the most susceptible to ozone. Reams 64, McNair 30, and NC 2512 displayed the highest level of ozone tolerance.

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INSECTS

Entomology Research Division, ARS

Problem. Insecticides employed to control insects that attack tobacco, particularly budworms, hornworms, flea beetles, and aphids, may cause undesirable residues on cured tobacco. These residues adhere to the leaf through commercial processing and some have been found in the mainstream of smoke from commercial cigarettes. Non-insecticidal methods for controlling insect pests of tobacco are urgently needed. Research on lures, light traps, sterilization techniques, other new approaches to control, and better utilization of predators, parasites, and diseases of tobacco insects should be intensified. Studies to find market-acceptable tobacco varieties that resist insect attack need more attention. Integrated control programs that lessen the possibility of undesirable residues should also be investigated more intensively.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program of basic and applied research on tobacco insects to develop effective control methods that will alleviate the residue problem on the harvested leaf. The research is cooperative with State and Federal entomologists, chemists, agronomists, and agricultural engineers in the States where research is underway and with the tobacco industry. Studies are conducted at Oxford, N.C., Florence, S.C., Quincy, Fla., and at a temporary location on St. Croix, Virgin Islands, a satellite of Oxford. Contract research supported by the Department is in progress at Kentucky, North Carolina, and South Carolina Agricultural Experiment Stations, and the Virginia Polytechnic Institute. A grant for studies on tobacco insects at the Clemson Agricultural Experiment Station in South Carolina and for work on tobacco flea beetles by the University of Florida Agricultural Experiment Station at Quincy have been implemented.

The Federal scientific effort devoted to research in this area totals 7.4 professional man-years. Of this number, 1.3 is devoted to basic biology, physiology, and nutrition; 1.7 to insecticidal and cultural control; 0.3 to insecticide residue determinations; 1.4 to biological control; 2.0 to insect sterility, attractants, and other new approaches to control; 0.1 to evaluation of equipment for insect detection and control; 0.2 to varietal evaluation for insect resistance; and 0.4 to program leadership.

In addition Federal support of research under contracts and grants provides 0.4 man-year in this area. This is devoted to basic biology, physiology, and nutrition.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 10.8 professional man-years is devoted to this area of research.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Basic Biology, Physiology, and Nutrition

1. Tobacco Budworm. The artificial diet developed by Berger (ARS-33-84), which has been used to rear the tobacco budworm at Oxford, N.C., has been estimated to cost about $1.74 per gallon. Preliminary tests have shown that casein, one of the main ingredients of Berger's diet, can be replaced by MNC(R), a dairy product of Foremost Dairies, Inc. Use of this product has lowered the cost of the diet to $1.05 per gallon.

Experiments now in progress indicate that when MNC is used in place of casein there is no longer a need for choline chloride or the salt mixture. Elimination of these ingredients will also help reduce the cost of the artificial diet.

At Quincy, Fla., 1 and 2-day-old laboratory-reared tobacco budworm moths were marked on the forewing with paint and released in the center of a 1-square-mile area in which 60 blacklight traps were distributed. Six percent of those released were recaptured in the square mile and 72% of the captures were taken the first night after release. Several moths were caught up to 7 days after release. A rearing facility has been completed at Quincy, Fla., to produce cabbage looper and tobacco budworms on a synthetic diet. Present equipment will allow production of approximately 5,000 of each species weekly.

2. Tobacco Hornworm. At Oxford, N.C., a study of 3 different substrates, dry paper toweling, wet paper toweling, and artificial diet, showed that the best hatch (greater than 70%) is obtained on a dry substrate. The wet substrate yielded a hatch that was 50% less and the artificial diet less than 50% of the wet substrate. By autoclaving the papers on which the eggs are placed and by treating the eggs with a 15-minute dip in sodium hypochlorite (0.5%) and placing these items in a plastic cup that has also been treated with sodium hypochlorite, it has been possible to increase hatch nearly to 90% and to maintain 75% recovery during the time the larvae remain in the plastic containers.

In a study of movement of tobacco hornworm moths on Hatteras Island, North Carolina, approximately 2,000 moths have been marked and released at distances from 0 to 12 miles from blacklight insect traps. Only one recapture has thus far been made. Four unmarked wild moths were captured, one on the mainland at Stumpy Point and 3 on Hatteras Island, near Rodanthe, N.C.

On St. Croix, Virgin Islands, recovery of marked moths indicated that dispersal was primarily in random directions, although flights across or into the wind predominated at times. Males released at varying distances and directions from caged virgin females frequently flew upwind to find the females. Upwind dispersal was believed to be predicated upon the perception of attractive odors. One flight of 14 miles in 2 nights was recorded.

Males of the St. Croix strain of tobacco hornworm were attracted to North Carolina females on the island of St. Croix, suggesting that a synthetic pheromone derived from North Carolina females can be used in an eradication feasibility trial on St. Croix. Placement of virgin female tobacco hornworms on or near light traps appreciably increased the number of males collected in the traps.

On St. Croix the hornworm undergoes a resting stage similar to diapause. Some prepupae placed in ground cages in October did not emerge as adults until the following May.

At Oxford, N.C., the entry of the hornworm larva into the soil was found to be accomplished by a combination of scooping movements of the head capsule and compression of the anterior region of the body into the depression thus formed, followed by extension of the body region anterior to the abdomen through a series of hydraulic ramming motions. The tunnel thus formed in front of the advancing head capsule is widened to accommodate the greater width of the body by the larva swinging the head from one side of the median line to the other. The angle of entry is oblique; twenty-five measurements made with a protractor lay within a range of 41 to 53 degrees. After the body is submerged, an abrupt geotactic orientation is made, and the descent continues in a vertical line if the substrate does not become packed too hard. Soil structure when unfavorable cause the larva to turn aside and a zig-zag route to pupation site is the result. Very few larvae of 100 observed made a perfectly vertical descent to pupation site presumably because of soil irregularities.

The behavior of mature hornworm larvae prior to entering soil was studied at Oxford, N.C. Shortly after the fifth instar larva ceases feeding and prior to burrowing into the soil it executes a series of maneuvers. First it rears up on the back pair, or back 2 pairs of thoracic legs, and makes chewing motions while holding the body rigid and motionless for as long as 2-3 minutes. The head is deflected sharply toward the ventral surface, and a viscous fluid exudate flows from the mouthparts between the labium and neck. The head is swung in a lateral arc and, in a series of short, jerky movements, the mouthparts are brought into contact with the body. The dorsal region of the head capsule is brought into firm contact with the dorsal surface of the body. Fluid which was previously deposited is forced between the opposed surfaces and flows over the dorsal surfaces of the thorax and head capsule. The mouthparts are applied to the ventral region of the first abdominal segment and moved in a series of short, recurrent arcs over the lateral surface and the dorsal region of the segment. This series of "licking" movements is continued to the last segment of the abdomen and the anal prolegs. The body is straightened and the process is repeated.

This fluid may act as an antibiotic and/or a moisture proofing coating, helping to prevent water loss during the period of chrysalis formation. It hardens upon exposure to the air and is soluble in the fluid which is exuded from the mouth.

Survival of pupae and size and vigor of the emerging adults appeared to be directly related to soil moisture. Partial desiccation resulted in slow development and greatly staggered emergence. In many instances the wings were not properly inflated and wing deformity occurred. In drier soils the larvae also lost body fluids in the process of establishing themselves at pupation sites that are required for metamorphosis.

3. Cabbage Looper. At Quincy, Fla., catches of male cabbage loopers in light traps baited with and without synthesized sex lure identical in composition with that naturally produced by female cabbage loopers were correlated with mean night temperatures, maximum temperature on day preceding catch, minimum soil temperature on night of catch, sunshine on day previous to catch, relative humidity, barometric pressure, cloudiness, and air movement. These are the weather elements considered to have the greatest influence on insect activity. In traps with light alone, cloud cover increased catches more than any other factor; moonlight decreased catches. However, when the sex attractant was added to blacklight, trap catches were greatly increased irrespective of moonlight or cloud cover. Low humidity, high air and soil temperatures, and air movements increased catches in the combination blacklight and sex attractant traps.

Also at Quincy, Fla., captured male cabbage loopers were marked and released in the center of a 1-square-mile test area. In this experiment 60 blacklight traps each were baited with 0.1 gram of the female looper sex lure. Ten percent of the marked moths were recovered; about 95% of the recaptures were taken in the 41 traps within the square-mile test area. Several moths were recaptured 3 to 4 miles from the release point and one was recaptured 13 miles away 2 days after release. A few moths were recaptured 7 days after release.

B. Insecticidal and Cultural Control

1. Wireworms. At Florence. S.C., a method was developed for control of wireworms in tobacco fields, employing a granular insecticide distributor attached to a tractor in such a way that the tractor would simultaneously apply granules as a row treatment and bed the row. Standard tractor equipment was used.

Field experiments have demonstrated that several new insecticides are effective wireworm control remedies when applied as granules. The most effective materials have been Bay 37289, Stauffer N-2790, Union Carbide UC 21149, Mobil V-C 9-104, a diazinon corn grits bait, Niagara NIA-10242, Chevron RE-5305, and Bay 25141. In cooperative work with the Crops Research Division, UC-21149 and Mobil VC 9-104 have also shown promise as a control remedy for the root knot nematode which attacks tobacco.

Disulfoton was an effective systemic insecticide for control of the tobacco flea beetle and green peach aphid on flue-cured tobacco when applied to the soil as a granule. Disulfoton has label registration for use on tobacco.

2. Green Peach Aphid and Tobacco Flea Beetle. At Florence, S.C., the most effective systemic insecticide for control of foliage feeding tobacco insects has been Niagara NIA-10242. This chemical when applied to the soil as granules has given good control of the tobacco flea beetle, the tobacco budworm, and the tobacco hornworm. The length of time the material remains effective has not been determined but has been effective for several weeks.

3. Tobacco Hornworms and Budworms. The influence of late season stalk cutting to prevent late season development of overwintering tobacco hornworm and budworm was continued in a 113-square-mile area at Florence, S.C. Growers cut 87% of their stalks in 1965 and 90% in 1966. The remaining stalks were cut by a commercial operator. Despite stalk destruction in 1966, a severe hornworm infestation developed in 1967 in the middle of the stalk cutting area. Hornworms produced throughout the tobacco growing area may have concentrated on this and other fields in which stalks were not destroyed in 1967. Movement of moths from outside the experimental area may also have been responsible for the infestation. Stalk destruction may need to be practiced throughout extensive tobacco-producing areas to be effective.

C. Insecticide Residue Determinations

1. Off-Taste and Flavor Studies. At Florence, S.C., there has been no off-taste or flavor in tobacco grown where the most promising soil treatments were used for wireworm control. The treatments have included a transplant water treatment containing diazinon wettable powder and granular formulations Bay 37289, Bay 25141, Stauffer N-2790, Union Carbide UC 21149, Mobil VC 9-104, and a 4 lb active ingredient rate of Niagara NIA-10242.

D. Biological Control

1. Cabbage Looper. At Quincy, Fla., application of a commercially prepared nuclear polyhedral virus as a dust on cigar wrapper tobacco for control of cabbage loopers was as effective as the standard insecticide treatments.

E. Insect Sterility, Attractants, and Other New Approaches to Control

1. Tobacco Hornworms and Budworms. At Oxford, N.C., hornworms were effectively sterilized with 35,000 rads of cobalt 60 irradiation administered late in the pupal stage. Field released sterile males dispersed and survived well; however, natural populations during the initial releases were low and meaningful sterility data were not obtained.

A flight chamber measuring 80' x 8' x 8' has been constructed at Oxford, N.C., and automatic humidity, temperature, and light control systems installed. A modified blacklight trap at one end of the chamber was equipped with an hourly sample changer so that the trap could be timed to run for any period up to 12 hours with samples collected automatically for each 12-hour period. The highest catch of diet reared male moths was 58% and occurred on the first day. The average catch of diet-reared males over a 4-day period was

40.5%. The highest catch of field-reared males was 38% and occurred on the second day. The average catch of field-reared males over a 6-day period was 25.5%. The highest catch of diet-reared virgin female moths was 17% and occurred on the second day. The average catch of virgin females over a 6-day period was 7.5%, which compares favorable with the 3.6% total of virgin female moths that were captured in 78 check traps in the integrated control area surrounding Oxford.

On St. Croix, Virgin Islands, about 250 UV light traps were in operation for they year to measure their effect on isolated insect populations. Thrice weekly counts of collections from 53 of these traps were made. Included in the counts were the tobacco hornworm, the tobacco budworm, the corn earworm, stink bugs, May beetles, and other insects, totaling over 30 species. The trapping appeared to suppress the populations of several species but did not eradicate them. For 6 months 11 plots of tobacco, corn, sugarcane, cucumber, cotton, and cabbage were maintained at representative locations on St. Croix to determine the density and distribution of insects attacking these crops and the effect of the light trap installation on population densities. The melonworm, pink bollworm, corn earworm, and fall armyworm were found to be abundant whenever suitable host material was present. Insects from 17 traps maintained on the islands of Culebra and Vieques near Puerto Rico and on St. John and St. Thomas in the Virgin Islands were collected and counted 3 times a week. The information obtained will serve as a basis for evaluating the control potential of blacklight and other population suppression measures involving integrated use of physical and chemical attractants, natural enemies, and other methods.

At Florence, S.C., field trap cage studies during 1966 and 1967 demonstrated that a chemical extract of a crude sex attractant is attractive to male tobacco hornworm moths. The chemical extract was prepared by the Zoology Department of the University of Wisconsin working under Entomology Research Division grant No. 12-14-100-7991 (33). The quantitative potency of this promising chemical extract has not been determined. It was obtained from a crude extract of virgin female tips clipped into ether, a process initiated at Florence in 1961.

At. Quincy, Fla., in a 1-square-mile area containing 41 blacklight traps, each baited with 0.1 gram of the female cabbage looper sex lure (100,000 female equivalents), male populations were drastically reduced. However, the number of mated females, eggs, and small larvae and percent egg hatch were not significantly less than in outside areas with 3 light traps per square mile.

2. Integrated Control. At Quincy, Fla., further evaluation of an integrated insect control program using disulfoton, light traps, the pathogen Bacillus thuringiensis and relatively nonpersistent insecticides as needed, reduced the number of insecticide applications on cigar wrapper tobacco by about 40%.

F. Evaluation of Equipment for Insect Detection and Control

1. Blacklight Traps. On St. Croix, Virgin Islands, battery operated blacklight traps collected as many hornworms as power line operated traps, despite the lower light intensity of the former, attesting to the reliability of data from experiments that included battery operated traps. Other insects that were equally or more attracted to the battery operated traps included May beetles, stink bugs, tobacco budworm, corn earworm, and Pseudoplusia includans.

The presence or absence of dead insects in the light trap collection baskets on St. Croix, Virgin Islands, did not affect the collection of hornworm moths. Fewer tobacco budworms and corn earworms were collected in baskets that were half full of dead insects.

There did not appear to be any interaction between iso amyl salycilate, a tobacco hornworm attractant, and the ultraviolet light of the traps. Collections of the tobacco hornworm and 6 other sphingids was not influenced by the chemical.

At Quincy, Fla., in cooperation with the Agricultural Engineering Research Division, 1, 2, 3, and 4 15-watt blacklight traps were baited with 0.1 gram of the female cabbage looper sex lure. Increase in wattage failed to improve the male cabbage looper catch; however, tobacco budworm and corn earworm catches increased with wattage.

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PLANTING, HARVESTING, CURING, AND INSECT CONTROL

Agricultural Engineering Research Division, ARS

Problem. The development of equipment and methods for efficiently producing, harvesting and farm handling tobacco with emphasis on the preservation of the inherent qualities of the tobacco during these processes, is necessary if the farmer in the United States is to compete effectively on both the domestic and foreign markets. With the supply of manpower for these operations becoming progressively less satisfactory, and with over 400 man-hours per acre required for tobacco production and handling, the need for mechanization is urgent. There is also need to develop better methods, techniques, and equipment for use on farms in preparing tobacco leaf for market so as to preserve quality, and to prevent spoilage and damage from mechanical handling. The basic underlying principles that pertain to the curing and sorting of tobacco need to be determined.

To minimize the use of possibly hazardous chemicals as much as possible, there is need for continued research on nonchemical methods for insect control. Further evaluation of electrical methods, alone or in combination with insecticides, chemosterilants, and biological attractants, is necessary.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving agricultural engineers engaged in both basic and applied research on the engineering phases of crop harvesting and handling, on farm processing methods, and on insect control. Tobacco harvesting, curing and sorting research is cooperative with the Experiment Station at Lexington, Kentucky. Investigation on electrical and physical methods of tobacco insect control are conducted in North Carolina, South Carolina, Kentucky, and Virginia.

There were 1.0 scientist man-years devoted to research on planting; 1.0 to harvesting; 1.0 to curing; and 3.0 to investigations on the use of light traps for tobacco insects.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

Several of the State Agricultural Experiment Stations are engaged in some aspect of basic or applied research concerned with improving machines and methods for efficient harvesting, farm handling, and curing of tobacco; and with using various electrical methods for the control of tobacco insects. Much of the research is cooperative with the Department. The research effort devoted to this area of research totals 6.0 scientist man-years.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Fertilizer Placement and Distribution Equipment

Research has been conducted under a grant to the North Carolina Station to control tobacco production and curing as related to health factors. Growth equipment is being developed to monitor growth continuously. Studies of effect of root temperature, gaseous composition in the root zone and soil moisture level were initiated. Field experiments were conducted in order to study modification in leaf properties due to harvest procedure. Samples are being evaluated by a cooperating tobacco company for major chemical and physical properties. Orders have been placed for two small environment test chambers for more precise laboratory curing studies.

B. Harvesting Equipment

Research was continued on the handling of stalk-cut tobacco on portable curing frames utilizing fork-lift techniques. An "on-the-farm" assembled steel portable curing frame has been developed. A sled having hydraulic-powered ejection of the filled frame was used to reduce labor required to place harvested tobacco into the frames. Four curing methods were used, (1) curing without supplemental heat in an air-cure barn, (2) curing with oil-fired automatically controlled heat in an air-cure barn, (3) curing with propane-fired automatically controlled heat in a forced-air ventilated barn, and (4) air-curing within temporary plastic enclosure attached to the portable curing frames. Experimental handling procedures involving forced-air required excessive fork-lift operator skill to accurately position the frames in the barn. Cured "out-of-case" tobacco was satisfactorily removed from the barn while in the frames, then placed into a plastic enclosure to be cased for market preparation using an evaporator heated by an automatically controlled burner. Labor required for field handling, transport between field to barn, housing, removal of cured tobacco from the barn, and casing with steam was 35 to 40 man-hours per acre. Mean value of tobacco air-cured without supplemental heat was 61 cents and 64 cents per pound when stick spacing was 5 and 6 inches, respectively. However, when supplemental heat was applied, the values of cured tobacco was 64 cents, regardless of stick interval. The use of steam to permit market preparation, regardless of weather conditions, had no significant effect upon the quality of the tobacco as indicated by government grade. During 1967 the handling system involving air-curing will be tested at farms of grower cooperators.

The objective of handling stalk-cut air-cured tobacco on vertically suspended strings is to design a harvest-housing system having efficient use of men and equipment. A system is proposed utilizing a tobacco harvester having the function to fasten the base of stalk-cut tobacco to continuous twine. "Chains" of stalks will hang from a rail system constructed near the top of an air-cure barn. Control and power circuits for hydraulic or hydraulic and pneumatic harvester components have been designed. Curing tests have indicated satisfactory air-cure using the proposed procedure of handling.

C. Curing

Curing burley tobacco under modified environmental conditions. Fan ventilation of regular tobacco barns was continued. Most of the conclusions reached in previous studies were further verified with one major exception. Supplementary heat units can and should be capable of creating more than a 10° to 12° F. temperature rise in the barn. This is especially necessary during cool damp curing periods as those experienced in 1966. However, during the early stages of the cure special care must be taken not to over use the extra heating capacity to the point of drying the tobacco too fast and setting green color in the leaf. Another problem with forced ventilation systems is lack of uniform density of the tobacco. Extra care must be taken during loading operations to assure uniform tobacco density along each rail and from one rail to another. Improved air distribution from the fan needs further study.

Curing primed burley tobacco. The objective was to compare two curing methods --primed-leaf curing and stalk-cut curing--on the basis of leaf-drying rates and physical and chemical characteristics of the leaf. This was a continuation of 1965 research. Leaves were primed at five biweekly intervals during the season. Based on standard grade analyses of the cured tobacco, the treatments were judged in order of preference as follows: (1) Stalk-cut, cured at constant conditions of 90° F., 70 percent r.h.; (2) primed-leaf, cured at 90° F., 80 percent r.h.; (3) primed-leaf, cured naturally; (4) primed-leaf, cured at 90° F., 60 percent r.h.; and (5) stalk-cut, cured naturally. Chemical analysis showed that a rapid decrease in protein nitrogen content of the leaf during the first three days of the cure was desirable. Samples for which the protein nitrogen decreased about 30 percent during the first three days and about 40 percent during the first six days were judged less desirable than samples for which protein nitrogen decreased about 40 percent in three days and 45 percent in six days. This compares with the expected decrease in protein nitrogen of 50 percent during normal curing. A comparison of chemical analyses at various leaf moisture contents indicated that chemical changes in leaf laminae were arrested at about 200 percent moisture content dry basis.

These results show that environmental control can be employed to manipulate desired physical and chemical changes in both primed and unprimed leaves.

Mass and energy balance of burley tobacco during the cure. The objective of this investigations is to obtain data for the design of controlled or modified environment curing structures for burley tobacco. This design will require knowledge of the basic properties of tobacco under various curing conditions. The major ventilation load of an air-cure system is the heat and moisture evaporated from the tobacco. Investigations indicated that 30 to 60 percent of the heat required to vaporize this water from the curing tobacco plant might be available as heat produced by respiration. The lack

of information reported in the literature and the potential application for the knowledge of respiration heat and moisture removal to a curing system prompted this study. A respiration calorimeter has been designed and constructed for measuring the effect of temperature, humidity, and air-flow on the mass and energy exchange between the curing tobacco plant and its environment.

Portable colorimeter for tobacco leaves. An instrument was sought which would be fast, portable, and inexpensive but would still give satisfactory results in evaluating the colorimetric properties of tobacco leaves. The principle of operation involves analysis of reflected light from the leaf sample. The reflected light passes through a colored filter to a selenium photocell. Light striking the photocell surface causes electrons to flow. This current is a measure of the intensity of light. Instrument data were converted to a standard color language system. The color system recommended by the 1931 International Commission on Illumination (ICI) was used. The proposed objectives of portability, speed, and low cost were met. The results, however, showed an error of $\pm$ 10 percent in the ICI color coordinates when compared to a Spectronic 505 spectrophotometer. This is not good enough for separating tobacco into exact grades; however, meaningful results could be obtained when comparing leaves, or in detecting changes in colorimetric properties during growth or curing.

D. Electric Traps for Tobacco Insects

Research on development and use of electric insect light traps for attracting and controlling tobacco insects was conducted at Blacksburg, Virginia, Oxford, North Carolina, Lexington, Kentucky, Saint Croix, Virgin Islands, Quincy, Florida, and Florence, South Carolina, per a contract with Clemson University. All work is cooperative with the Entomology Research Division and, except for that at Saint Croix, with State agricultural experiment stations.

At Blacksburg, Virginia, electrophysiological studies on the visual sensitivity of the tobacco hornworm moth, Manduca sexta (Johannson), were continued. Most of the observations are based on data obtained from male moths because of a shortage of female pupae. Utilizing the electroretinogram (ERG), the spectral sensitivity of this moth was determined between 340 and 600 nanometer wavelength range. A major sensitivity peak occurs at 550 nanometer in the visible spectrum with minor peaks occurring at approximately 500 and 370 nanometer in the visible and ultraviolet spectrums, respectively. These peaks continue to occur with a tenfold increase in the irradiation level. Findings do not indicate if moths are attracted or repelled at these wavelengths. Moths reared on a carotene deficient diet have responded much less to irradiations between 340 and 600 nanometer than moths from a natural population and have appeared to be practically blind. A study of the eyes of these moths using light and electron microscopes shows damaged structure of many parts. This has not been observed in moths reared on regular diets.

ERG studies of male moths caught in sex attractant traps showed patterns similar to those from moths of natural populations. Studies are being conducted to determine the response from nerves serving flight muscles when the eye is irradiated at various wavelengths between 340 and 600 nanometer. Entomological studies of the tobacco hornworm moth have revealed structural evidence of a sound receptor. Sonic analysis will be made.

At Oxford, North Carolina, investigations to determine the effectiveness of insect light traps distributed over large areas to control or reduce tobacco insects continued during 1966 in cooperation with Entomology Research Division. The physical installation and the method of operation was essentially the same as used in the 1965 studies.

Preliminary analysis of the 1966 data indicate trends very similar to those found during prior years of operation except that estimated reductions, in general, were somewhat higher, possibly indicating a yearly accumulative effect of light traps in reducing tobacco insect populations. Calculated reductions for hornworms between 20 and 0 miles from the center of the area were 70 percent for the female tomato, 86 percent for the male tomato, 86 percent for the female tobacco, and 100 percent for the male tobacco hornworms. Calculated reductions, based on field counts in noninsecticide treated tobacco plots, between the above-mentioned distances were 99 percent for hornworm eggs and first instar worms on tobacco and 77 percent for hornworm damage to tobacco plants. Similarly, budworm egg and damage count on untreated tobacco showed calculated reductions of 64 and 43 percent, respectively. As was the case last year, the estimated average number of insecticide applications to tobacco was greater outside than inside the light trap area.

Preliminary data from two farmer-owned, large-area light trap installations in North Carolina indicate a suppression of tobacco insects similar to the Oxford installation when the farmer traps were maintained in good repair.

Results of tests using insect light traps in open areas, edge of wooded areas, and wooded areas, indicate a distribution of about 72 percent, 25 percent, and 3 percent, respectively, for the tobacco hornworms within these areas. Corn earworms captured in these tests indicated a distribution of about 56 percent, 38 percent, and 6 percent, respectively.

Insects captured in light traps spaced at 10-foot intervals on a fire tower indicate a fairly uniform vertical distribution of hornworms from 10 to 90 feet. However, corn earworms appear to be slightly more abundant at the higher levels.

Investigations at Lexington, Kentucky, related to the evaluation of electric insect traps for controlling tobacco insects were continued. The objectives were to determine if an areawide program of electric insect traps with a fairly uniform density of three traps per square mile over a 100-square-mile area would reduce or possibly eliminate the need for chemical applications in controlling hornworms in tobacco and to evaluate the efficiency of experimentally designed insect traps for attracting and catching hornworm moths. This work was cooperative with the Kentucky Agricultural Experiment Station through the Departments of Entomology and Botany, and Agricultural Engineering. Farmers in Shelby County cooperated by purchasing and installing the traps. The method of evaluating degrees of control was by checking the number of hornworm eggs and larvae in one-half acre experimental plots of tobacco. Although the hornworm moth catches had a fairly good regression line from outside to inside and more eggs and larvae were detected outside the area than inside, no definite regression line of eggs and larvae versus distance from the center of the control area was established.

Area control studies were started on Saint Croix. Data have revealed a decrease in light trap catches as the moon increases in brightness and a converse relation as the moon wanes. Wind has a significant influence on insect activity which apparently reduces the trap catches as its intensity increases. Individual light trap catches of specific insects have varied considerably with an erratic fluctuation among traps. These factors will be analyzed as additional personnel become available by transfer to the project.

At Quincy, Florida, fields of shade-grown tobacco receiving an integrated control program consisting of light traps placed around the outside of the field; a pre-plant systemic insecticide treatment; a virus, Bacillus thuringiensis, and relatively nonpersistent insecticides received no greater budworm and cabbage looper damage than check fields on which significantly more applications of insecticides were applied. Data obtained from an entomological survey in an area of farmer-operated light traps revealed a 10-20 percent reduction in insecticide applications.

Engineering activity at Florence, South Carolina, involved efforts to determine the condition of farmer-operated light trapping equipment being evaluated by ENT as an area population control measure. The state of repair of traps was found to vary considerably with some units ineffective in retaining insects. Extensive educational and adequate maintenance programs are required to enable light traps to function at full capability.

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II. CONSUMER AND INDUSTRIAL USE RESEARCH

TOBACCO UTILIZATION - INDUSTRIAL PRODUCTS

Eastern Utilization Research and Development Division, ARS

Problem. Although neither food nor fiber, tobacco nevertheless is grown on about a million acres, and in seven states provided more farm cash receipts than any other field crop in 1964. The farm value is about $1.3 billion. This crop is unique in that it yields about $3.1 billion in Federal and State taxes. Of the problems affecting the tobacco industry, the much publicized charges concerning the effect of tobacco usage on health are the most serious. Although much controversy still surrounds these charges, the importance of the tobacco economy and the seriousness of the charges dictate that research in this area be intensified. Such a program will serve to elucidate more completely the extent of smoking-health relationships and the capabilities of research to alter the observed physiological effects of smoke on animal tissue. Information obtained in such studies may also be of value in other industrial problems, such as the determination of relationships between the chemical composition of tobacco and smoke, and the overall quality of tobacco products. It should be noted that the present program represents a significant reorientation of effort from past endeavor concerned mainly with quality problems.

USDA AND COOPERATIVE PROGRAM

The Department has an expanding program involving many facets of the chemistry and biology of tobacco and its smoke. Much of the work is basic in nature and, although the program is health-oriented, many findings of value in industrial problems not related to health may be forthcoming. The present program is divided into six general areas: basic studies on the composition of cigarette smoke; similar investigations on tobacco leaf; biochemical changes during fermentation and aging; the nature of the pyrolytic products from leaf substances or fractions; the effect of chemical additives on the composition of cigarette smoke; and biomedical studies related to the biological assaying of cigarette smoke.

The Federal scientific effort devoted to research in this area totals 36.8 scientist man-years, including 21 of contract research. This effort is applied as follows:

Chemical composition, physical properties and structure investigations involves 5.4 scientist man-years at Wyndmoor, Pennsylvania, on composition of cigarette smoke and acids and bases in cigar smoke.

Contract research includes 1.4 scientist man-years effort at Durham, North Carolina, on a study of neutral resins of tobacco leaf and three projects at the University of Kentucky, Lexington, totaling 3.2 scientist man-years on aromatic hydrocarbons, heterocyclic bases and nitrosamines in smoke.

Chemical and physical investigations to improve products involves a total of 15.6 scientist man-years, including 11.6 of contract research at the University of Kentucky. The program includes evaluation of cigarette modifiers, study of pyrolytic products and development of assaying procedures with emphasis on improved biological assaying methods.

Microbiology and fermentation involves 5.2 scientist man-years at Wyndmoor on a study of biochemical changes in tobacco during aging and fermentation.

Research on technology - process and product development involves a total of 6.0 scientist man-years. This effort includes 1.2 scientist man-years at Wyndmoor on large-scale production of samples for biological assays and other studies, 1.2 scientist man-years of contract research with Houdry Process and Chemical Company, Linwood, Pa., to develop additives to modify cigarette burn temperatures, contract research of 0.9 scientist man-year at Health Research Institute, Buffalo, N. Y., and 1.3 at University of Kentucky pertaining to application of bioassay methods, and 1.4 at the University of Kentucky for production of experimental cigarettes and preparation of smoke condensates therefrom.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 8.9 scientist man-years is devoted to this area of research.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition, Physical Properties and Structure

1. Composition of tobacco smoke. Significant chemical differences were found in the smoke of four custom cigars which varied only in the origin (Pennsylvania, Puerto Rico, Columbia and Dominican Republic) of the unblended filler tobacco. Quantitative comparisons were based on analysis of more than 30 compounds. Smoke from cigars made with Pennsylvania filler contained the highest levels of nicotine and related alkaloids. Smoke from the Columbian filler was highest in isoprene and related terpenes and in phenylacetic acid. Dominican Republic tobacco smoke was lower in carboxylic acids than the other three. The Columbian cigar is the most chemically unique and appears, based on preliminary subjective panel testing, to be the most characteristic in smoking quality.

In research on the composition of cigarette smoke, work has continued on the study of structure and properties of the high molecular weight pigment isolated from smoke condensate. A subfraction of the pigment was demonstrated to contain a silicone and 22 heterocyclic bases, including nicotine and four other alkaloids.

This represents the first report of the occurrence of nicotine and other alkaloids found in high molecular weight form in cigarette smoke.

In other studies of the composition of smoke condensate, four aromatic amines were identified: N-phenyl-2-naphthylamine, N-phenyl-4-isopropylphenylamine, diphenylamine and 9,9-dimethylacridan.

Except for aniline, the occurrence of aromatic amines in cigarette smoke condensate has not previously been shown.

In contract research at the University of Kentucky Research Foundation, Lexington, selective fractionation and separation of the polynuclear aromatic hydrocarbons in cigarette smoke condensate showed the presence of more than 20 compounds. Among those identified are phenanthrene, fluoranthene, pyrene, chrysene, benzo(b)fluoranthene, benzo(a)pyrene, dibenz(a,h)anthracene, and dibenzo(a,i)pyrene. Benzo(a)pyrene and other polymeric aromatic hydrocarbons were detected in quantities as low as 10^{-8} gram.

The literature values for benzo(a)pyrene in cigarette smoke are, however, probably lower than the content of this compound in the smoke. In developing an improved method for the determination of polynuclear hydrocarbons in cigarette smoke, the separation of a mixture of known amounts of authentic compounds was investigated. Data obtained in the recovery studies showed that the procedures had certain limitations and that losses were incurred during chromatographic separations.

2. Composition of tobacco leaf. In contract research at the Research Triangle Institute, at Durham, North Carolina, on the "neutral resins" of tobacco leaf, levulinic acid was isolated from this source for the first time. Several other acids are indicated to be constituents of tobacco leaf. In another phase of the research to separate components of the complicated neutral resin fraction, a countercurrent distribution procedure was applied to a subfraction to obtain esters and non-polar alcohols, alkaloids and polar alcohols.

Cigar leaf tobaccos grown in different geographical locations were found to have characteristic differences in chemical composition. Pennsylvania filler was lowest in solanesol and the Columbian filler was highest in unidentified constituents. The free amino acid pattern in the Pennsylvania and Columbian filler was also distinctly different from the Puerto Rican and Dominican types.

B. Chemical and Physical Investigations to Improve Products

1. Cigarette modifiers. Cooperative research at the University of Kentucky, Lexington, on the evaluation of cigarette modifiers suggests that the amount of at least one deleterious substance in cigarette smoke (benzo(a)pyrene) can be altered by crop fertilization. Cigarettes manufactured from burley tobacco

grown under low and high levels of nitrate fertilization were analyzed and the latter were found to have a 17-fold greater content of naturally occurring nitrate. The amount of benzo(a)pyrene in the smoke of high nitrate fertilized tobacco was only 0.85 μg/100 cigarettes. For the low nitrate fertilized tobacco, however, the benzo(a)pyrene content of the smoke was 6.1 μg/100 cigarettes. It therefore appears that less benzo(a)pyrene is produced when tobacco high in nitrate is burned.

2. Pyrolytic products. Pyrolysis studies with components of tobacco leaf provide a basis for correlating leaf source with product constituents in smoke. Tobacco leaf pigment has been shown, for the first time, to be a highly efficient phenol precursor. Other pyrolytic sources of phenol include lignin, pectin, cellulose, lysine and phenylalanine. The latter sources are part of the results from research on pyrolysis of amino acids at the University of Kentucky Research Foundation. At temperatures simulating that of a burning cigarette, benzo(a)pyrene and other polynuclear aromatic compounds are produced. Compounds studied included lysine monohydrochloride, leucine, phenylalanine, tryptophan and pyrrole. Low molecular weight carbon compounds, such as methane, ethylene, acetylene, and carbon monoxide, were identified in the gas evolved during pyrolysis of tryptophan and lysine.

3. Biological assay methods. In contract research at the University of Kentucky Research Foundation, Lexington, progress was made in the various independent biomedical studies which may serve as a basis for the development of new and improved biological assay methods. Currently, rat tracheal epithelial rings can be cultured for periods up to 10 days. This has permitted a day-to-day study of characteristic cell changes over this period.

Results of initial studies on the effect of smoking on saliva showed that the thiocyanate ion (SCN) concentration was significantly higher in saliva from smokers. The antibacterial activity of smokers' saliva to Lactobacillus acidolphilus has been correlated with the thiocyanate concentration. Techniques developed in this study will be useful in determining the antibacterial effect of smokers' saliva on other organisms of the oral cavity.

A technique for evaluating absorption through the cheek pouch of hamsters has been developed.

Research to study the apparent tumor-inducing property of viruses has been continued. In addition to the previously reported activity of influenza virus, other studies indicate that a virus (or virus-like agent) is associated with methylcholanthrene-induced fibrosarcomas in mice.

The oral administration of phenanthrene, a possible anticarcinogen, prior to the oral administration of labelled benzo(a)pyrene results in decreased amounts of benzo(a)pyrene in certain target tissues. The basis for this effect of phenanthrene is unknown, but presumably involves competition for transport mechanisms or binding sites in the target tissue.

In research on absorption of carcinogens and structurally-related noncarcinogens, investigations were conducted with 3-methylcholanthrene to develop procedures for detecting polycyclic hydrocarbons in the lungs, stomach, and small and large intestines of rodents.

Studies have been initiated to compare the suitability of the colchicine and tritiated thymidine techniques for determining respiratory cell turn-over rates in inbred mice. With each agent the first evidence of mitotic activity was found six hours after the agent was injected. Tissue sections were examined to establish how much lung tissue has to be studied and whether one area differs from another. Bronchial epithelial cells from primary, secondary and tertiary bronchi were counted and the minimum number of cells which must be counted to determine cell turnover was established. This information should be of value in expediting valid determinations of rates.

C. Microbiology and Fermentation

A project to study the biochemistry of tobacco fermentation and aging was initiated recently. Aqueous extracts of fermented tobacco leaf appear to be extremely low in protein content and high in carbohydrate.

An investigation was begun on the possible presence of mycotoxins in tobacco. Thin-layer chromotography of extracts of mold-infected tobacco leaf indicate the presence of components apparently not found in normal tobacco.

D. Technology - Process and Product Development

1. Modification of cigarette burn temperature. The study of the effect of additives on the burn temperature of cigarettes was continued under a contract at Houdry Process and Chemical Company, Marcus Hook, Pennsylvania. The addition of elemental sulfur or benzothiazyl disulfide to cigarette tobacco caused an elevation of burn temperature.

The most successful depressions of cigarette burn temperatures to date have been obtained with lead borate glass (previously reported), basic magnesium carbonate and nickel oxalate. A large number of cigarettes containing these burn temperature depressants were prepared for studies on changes in smoke condensate composition at the University of Kentucky.

2. Production of experimental cigarettes and smoke condensates. Contract research at the University of Kentucky Research Foundation, Lexington, provides for manufacturing experimental cigarettes and for preparing cigarette smoke condensates. The cigarette-making machines have not arrived, but two of the smoking machines have been received and are in operation.

Cigarettes manufactured by a commercial company from burley tobacco grown under high and low rates of nitrogen fertilization were received from the Crops Research Division. These cigarettes were smoked and condensates prepared for use in composition and bioassay studies.(See results reported under B-1, cigarette modifiers.)

Large-scale fractionations of smoke condensate, currently totaling about 6 kilos, have been conducted at Wyndmoor to supply samples for the bioassay test by Health Research, Inc., at Orchard Park (Buffalo), New York.

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III. MARKETING AND ECONOMIC RESEARCH

MARKET QUALITY

Market Quality Research Division, ARS

Problem. Stored tobacco and tobacco products are subject to insect damage that seriously affects the grade, value, and potential end use. The price support program continues to cause a large buildup of stocks, some held about twice the normal period for aging and storage. The long-term storage and the compact, dense structure of the tobacco in the storage hogsheads make insect control difficult. Repeated, heavy applications of fumigants and insecticides during storage has raised questions about the amount, nature, and significance of residues that may accumulate. Treatments applied during storage should be investigated in greater depth to be sure they are safe. Problems associated with tobacco fumigation in commercial channels have become acute during the past year. It was found that insect kill at the interior of hogsheads was less than anticipated. There were also some injuries to workers exposed to gas coming out of insufficiently aerated hogsheads. It is imperative that safe, effective procedures be developed. The advent of containerized shipping of export tobacco brings up new problems of insect control, particularly of fumigation. It is necessary to find the amount and rate of gas penetration and aeration in the large 20- by 40-foot metal containers. Attention should also be given to developing procedures for preventing or controlling insect infestations by means that will minimize or eliminate the use of toxic chemicals. To accomplish this it will be necessary to develop much more basic information on the ecology, physiology, and behavior of the insects that attack stored tobacco. Various fungi, bacteria, and viruses are found in tobacco. It is becoming quite apparent that the quantity of phenolic compounds is increased markedly in diseased plant tissue, including tobacco leaf. These substances may affect mammalian physiology. Research is needed to determine the changes that occur in the composition of tobacco leaf as the result of the metabolic activities of pathogens and to characterize the organisms that constitute the nonpathogenic microflora associated with tobacco leaves.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program headquartered at Richmond, Virginia, involving basic and applied research in entomology, directed toward the insect problems of tobacco and tobacco products in the marketing channels. The research is conducted in cooperation with farmers' cooperative associations, industry groups, and the Agricultural Stabilization and Conservation Service of this Department. The Federal effort devoted to this program is temporarily only 1.0 scientist man-year because of the inability to find

qualified personnel to fill two vacancies. Some of the cross-commodity research reported in Area 13, "Insect Control in Marketing Channels," applies to the insect problems in stored tobacco.

Line Project MQ 1-37, a study of flowing steam under vacuum to control tobacco insects, was terminated April 19, 1967.

The Department is conducting quality research at Raleigh, North Carolina, and under contract and cooperative agreement with the Agricultural Experiment Station of the University of Kentucky, Lexington, Kentucky. Federal effort amounts to 5.2 scientist man-years, of which 3 is by contract and 1.2 by cooperative agreement.

PROGRAM OF STATE EXPERIMENT STATIONS

The research effort of the State experiment stations in this area totals 1.0 scientist man-years.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Prevention of insect infestation

1. Biological and Physical Control. Many cigarette factories have converted to the use of flowing steam under vacuum for moisture conditioning their tobacco. Although field evaluation research was not completed when the basic research data were published, the industry was convinced of the merits of this method of moisture conditioning as a means of also obtaining insect control. As far as is known, the companies have had no problem with insect survival in the tobacco conditioned by this process. (MQ 1-37)

Third-instar larvae of the cigarette beetle were found to be more adversely affected by low temperatures than were those in the fourth instar. The larvae were exposed individually, each in ½ gram of cornmeal rearing medium. All third-instar larvae were dead in 3 weeks of exposure to 40° or 45° F., and 70-80% relative humidity, 8 weeks at 50° and 55% r.h., and 12 weeks at 50° and 65% r.h. All fourth-instar larvae were dead in 3 weeks at 40°, 4 weeks at 45°, 20 weeks at 50° and 55% r.h., and 24 weeks at 50° and 65% r.h. (MQ 1-7(Rev.))

Hogsheads of flue-cured tobacco hands that had become heavily infested with the cigarette beetle in storage were exposed to constant temperatures of 40°, 45°, and 48° F. The humidity was kept high so the tobacco moisture content was between 12 and 15 percent. Temperatures were monitored at 4-, 12-, and 20-inch depths in the hogsheads and dropped to those of the test rooms in 3 to 4 weeks. Examinations were made each 4 weeks for living insects. Pupae were more susceptible to the cold than were third-instar

larvae. Adults and fourth-instar larvae were about equal in resistance to cold and both were highly tolerant. At 40°, 45°, and 48° F., exposures of 12, 20, and 32 weeks, respectively, were necessary to kill all cigarette beetles infesting the hogsheads. In other temperature observations it was found that the temperature of heavily infested hogsheads of tobacco in normal storage exceeded the warehouse temperature as much as 25° F., during the 6- to 8-week preconditioning period and were 8° to 12° F. higher than uninfested hogsheads in the spring. Hogsheads with only light or moderate infestations were within 2° of the warehouse temperature. (MQ 1-7(Rev.))

Environmental studies of the temperature and moisture in tobacco hogsheads as influenced by outside and warehouse temperatures and relative humidity have been conducted at Wilson, North Carolina, since December 1966. Conditions are monitored at different depths in the hogsheads and at different heights above the floor. Information from these observations, coupled with that from laboratory studies of temperature and humidity effects, will provide a better understanding of the relationships of infestation in warehouse storage. This in turn could lead to preventive or control measures based on the manipulation or control of environmental factors. (MQ 1-7(Rev.))

2. Improved Pesticidal Control. Eight compounds were evaluated against adult cigarette beetles. The residue of Geigy 12968 was still effective after aging 24 months. Compounds with residues effective 6 to 12 months were Bayer 37343 and Bayer 77488, Shell SD 8211, and Shell 8447. Ciba 2428 was the only compound with significant vapor toxicity. None was effective as a repellent or attractant. (MQ 1-35)

All 1960 crop tobacco has now been sold from a number of warehouses that have been under observation. That fumigated yearly with HCN at 3 lb./1,000 cu. ft. and treated biweekly with dichlorvos during the summer showed, at most, only trace amounts of insect damage at time of sale. Tobacco similarly protected with dichlorvos but with more frequent HCN fumigations at a 1-lb. rate suffered damage ranging from trace amounts to very heavy. Some hogsheads had to be removed from stock and sold at discount because of excessive insect damage. The higher fumigation rate is now being used in more warehouses, especially in the southern part of the flue-cured tobacco storage belt. A series of warehouses fumigated in the spring with the 3-lb. dosage of HCN and given daily dichlorvos applications remained insect-free the first summer of storage. Cigarette beetles began to appear by August of the second summer. Even with daily dichlorvos applications, a heavy fumigation may be required every second year to protect the tobacco. (Exploratory)

Observations on the efficacy of some commercial vacuum fumigations revealed that neither HCN nor acrylonitrile was giving consistent kill of fourth-instar cigarette beetle larvae at depths greater than 10 inches in tobacco hogsheads. HCN appeared to be slightly more effective than acrylonitrile at the dosages used. The penetration and kill were improved by: (1) fumigating at 1-1½ inches of absolute pressure instead of 4-10 inches, (2) increasing the temperature in the fumigant volatilizer to 210-215° F. rather than 150°, and (3) reducing the flow rate of fumigant through the volatilizer. (Exploratory)

B. Quality maintenance

1. Effect of Postharvest Microflora on Tobacco Composition. A total of 2,382 isolates were obtained from 7 grades of aged burley tobacco. The microflora composition consisted of Aspergillus (31.5%), Penicillium (11.4%), yeast (20.5%), and bacterial species (29.1%). Aspergillus flvaus was the largest single species isolated (25.5%). Isolates of A. flavus were analyzed for their aflatoxin producing potential by chromatography and bioassay against Bacillus megaterium. Extracts of four isolates had Rf values similar to aflatoxin B_1 and G_1 standards and produced zones of inhibition when bioassayed against the aflatoxin sensitive bacteria. (MQ 2-109)

2. Microflora on Flue-Cured Tobacco and Their Affect on Quality. Isolations made from leaf tissue prior to and following flue-curing indicate that: (a) the predominant fungi isolated during 1966 were Alternaria, Aspergillus, Chaetomium, Cladosporium, Epicoccum, Nigrospora, Penicillium, Rhizopus, and Trichoderma; (b) Alternaria, Epicoccum, and Cladosporium represented 70% of all cultures obtained; (c) Alternaria and Cladosporium were reduced, but not eliminated, by flue-curing; (d) flue-curing did not reduce Epicoccum; and (e) Aspergillus ruber was isolated once from tobacco prior to flue-curing and almost 100 times following flue-curing, indicating that A. ruber apparently invades tobacco during or following flue-curing.

Nineteen genera of filamentous fungi (including 9 species of Aspergillus) were isolated from 51 samples of "moldy" tobacco received from a commercial tobacco company during the summer and fall of 1966. Aspergillus and Penicillium appeared to be the principal fungi responsible for deterioration, and tobacco moisture content appeared to determine which fungus species predominated as the main organism of deterioration.

A total of 1,372 cultures (1,206 fungi and 166 bacteria) from harvested, cured, or stored flue-cured type tobacco were tested for their ability to produce, in culture, materials toxic to warm blooded animals. An homogenate

of the micro-organisms and the culture medium was injected into mice interperitoneally. Tests made on 24 genera, including 8 species of Aspergillus, showed the following results: (a) 46% of the micro-organisms produced toxic metabolites; (b) Alternaria and Epicoccum produced the highest concentrations of toxic metabolites; and (c) 94% of the isolates of Epicoccum were toxic compared to only 51% of the isolates of Alternaria. (MQ 2-137(CA))

PUBLICATIONS--USDA AND COOPERATIVE RESEARCH

Prevention of Insect Infestation

Childs, Dana P. 1966. Laboratory evaluation of insecticides against the cigarette beetle. Jour. of Econ. Ent. 59(4): 846-849. (MQ 1-35)

Childs, Dana P. 1966. Effect on the tobacco moth of flowing steam vapor under vacuum. Tobacco Science, Vol. 10, pp. 113-115, In Tobacco 163(12): 30-32. (MQ 1-37)

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Childs, Dana P., and James E. Overby. 1967. Atmospheric chamber fumigation of cigar tobacco against the cigarette beetle. Tobacco Science, Vol. 11, pp. 38-41, In Tobacco 164(11): 30-33. (BS 1-69)

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MARKETING FACILITIES, EQUIPMENT AND METHODS

Transportation and Facilities Research Division, ARS

Problem. New or modified marketing facilities, equipment, and methods are essential to the efficient and economical handling, conditioning, and storing of tobacco and to maintaining tobacco quality. There is also a need for handling and conditioning equipment which will minimize labor and other costs. More knowledge is needed of the relative efficiency of various handling and conditioning methods so that improved or revised methods and equipment can be developed to perform necessary operations.

USDA PROGRAM

The Department initiated research at Raleigh, North Carolina, in December, 1965, to improve work methods, techniques, operating procedures, layouts, and equipment for handling tobacco in warehouses (sales floors), in cooperation with the North Carolina Agricultural Experiment Station and selected warehouses. This program is supplemented by research and broad-farm cooperative agreements with the North Carolina station and the Carolina Warehouse, Incorporated, Fuquay-Varina, North Carolina. The Federal effort devoted to tobacco research in this area during the fiscal year 1966 totaled 1.2 scientist man-year.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

Handling Tobacco in Warehouses and Storage of Unprocessed Tobacco

1. At Raleigh, N. C., an experimental tobacco handling system for use on sales floors was tested under actual commercial operating conditions each day of the tobacco marketing season at Carolina Warehouse in Fuquay-Varina, N. C. The system included equipment and procedures for receiving, storing, grading, selling and loading out tobacco.

Single-line, gravity-roller conveyors were installed to move baskets of tobacco from the truck unloading area across an elevated floor scale to a pickup station. The conveyors, using 2 1/2-inch diameter rollers on 4-inch centers, were sloped 1/2-inch per foot in direction of travel except for the level section on the scale platform. About 48 inches of conveyor space was needed for each 42-inch basket of tobacco. Each basket rolled by gravity from the farmer's truck to the scale where it was weighed and records prepared in the normal manner. After weighing, the basket moved on a 90-degree curved conveyor to a pickup station where it was moved by forklift truck to temporary storage on the warehouse floor.

Shortly before the sale individual baskets were placed by forklift truck on a gravity-roller conveyor line that extended through a grading room equipped with artificial daylight, where the tobacco was graded, directly into a sales room equipped with daylight grading lights, comfort air conditioning, and a variable-speed belt conveyor with a range of 180 to 800 baskets per hour. A single-line, gravity-roller conveyor was installed from the sales room to the load out area. The load out operation was planned so that after one basket automatically rolled onto a jack (dolly), a second basket was to be manually placed atop the first. As labor was not available during the 1966 selling season, an alternative method was used whereby the conveyor line beyond the sales room was extended to hold 50 baskets. Seven hundred and eighteen baskets of tobacco marketed by 33 farmers were sold through the system. Spillage of looseleaf tobacco handled through the system totaled only 0.4 percent. Tobacco sold through the experimental system averaged 67.9 cents per pound compared with the Fuquay market average of 66.7 cents for the same grades.

2. Under a research cooperative agreement with North Carolina Agricultural Experiment Station, "green" unprocessed tobacco was placed under storage at Oxford, N. C. in November 1966 in a packhouse simulating typical storage conditions for "hold over" tobacco. Seven lots of flue-cured tobacco, each weighing approximately 100 pounds, representing cured tobacco harvested from top to bottom of the plant were placed in storage to begin a hold over period from one marketing season to the next. Official Federal grades were placed on each lot, then the lots segregated by moisture content ranging from a low of 14 percent to a high of 24 percent. After 8 months' storage, no spoilage has occurred in the lots having a high moisture content nor has an insect infestation been observed. However, condensation occurred at intervals on the inside of the polyethylene film which caused a "crusty" condition on a thin layer of the adjacent tobacco. No off color, off aroma, or spoilage has occurred.

PUBLICATIONS--USDA AND COOPERATIVE RESEARCH

Graves, A. H. 1967. Tobacco Handling in Warehouse Sales Floors. North Carolina Agricultural Experiment Station, 1966 Annual Report.

ORGANIZATION AND PERFORMANCE OF MARKETS

Marketing Economics Research Division, ERS

Problem. Economic research in agricultural marketing furnishes information which serves as a basis for developing a more efficient system of marketing farm products from the producer to the consumer, providing equitable returns for both farms and marketing agencies. With the changing nature and structure of agriculture the capacity to adjust and cope with the dynamics of modern marketing is required increasingly of producers and distributors. Marketing economics research provides a service of collecting and analyzing information furnishing in an objective manner a form of market intelligence.

Comprehensive market information is developed in such areas as changes in the structure of the market and resulting impact on producers, processors, and distributors; farm retail-spreads and related measures of market performance; competition and pricing and the degree to which the marketing system effectively and equitably allocates payment for services performed; market power and effect of concentration, mergers, and acquisitions in diminishing or increasing bargaining opportunities between buyers and sellers; the introduction of new products and their impact on the structure of the industry; effects of changing transportation rates on the location of processing firms as well as producers of raw products.

Such studies furnish a basis for adjusting to change and keeping abreast of technological and scientific developments. Likewise, the studies provide a sound basis for both private and public policy decisions as they relate to marketing.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program of economic research providing information which is utilized for increasing the efficiency of the marketing system, as well as assuring equitable returns among producers, handlers, and distributors. It includes basic and applied research concerning either or both short-term, service-type work and long-term research problems. In fiscal year 1967, 1.9 scientist man-years were devoted to research in this area.

PROGRAM OF STATE EXPERIMENT STATIONS

There were 2.1 scientist man-years devoted to research on tobacco in this area.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A study which began for ASCS in July 1967 to determine cost of handling, processing and storing tobacco is well underway. Costs to be determined are: (1) Handling from warehouse auction floor to processing plant; (2) processing tobacco through stemming and redrying, including packing into storage containers and delivering to storage warehouses; and (3) storing and services incidental to storage operations, including sampling and reweighing of tobacco and additional packaging requirements necessary for all types of shipment.

Changing requirements for tobaccos in the manufacture of cigarettes, due to changes in the types of cigarettes produced and to technological advances in the manufacture of cigarettes, have resulted in a growing disparity between the Federal and commercial grading systems for tobacco. A mathematical simulation model of the cigarette manufacturing industry, designed to relate tobacco strip specifications for specific cigarette blends to leaf tobacco grades, and to indicate the commercial value of specific grades of leaf tobacco is under development. Work on this model has not yet reached the preliminary testing stage.

PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS

Brown, J. W. H., October 1966. Tobacco Marketing. ERS-326, 15 pp. (Reprinted from Agricultural Markets in Change, AER-95).

FARM COSTS AND RETURNS

Farm Production and Economics Division, ERS

Problem. In this period of rapid change in American agriculture, it is important to have comprehensive, reliable, current, and historical data on representative or typical farms in major tobacco growing areas. Physical and economic data needed include: Farm size, land use, livestock numbers, production, investment, prices received and quantities sold, prices paid and quantities purchased, and net returns. Such information is essential for intelligent policy and operating decisions by the agencies and industries serving agriculture and by farmers themselves.

USDA AND COOPERATIVE PROGRAM

Costs and returns by major types of farms is a continuing study of operations of typical or representative commercial farms to determine changes in size of farm, organization, investment, productivity, receipts, expenses, net farm income, physical inputs, farm output, prices received for products sold, and prices paid for goods and services used in production. Budgets are prepared annually to provide current information. Estimates for earlier years are revised as new information becomes available. Analyses are continually underway to show the effects of economic and technological changes on land, labor and capital requirements, production, production efficiency, and incomes of typical or representative commercial farms. Formal cooperation is maintained with the Kentucky and Tennessee Experiment Stations.

Approximately 1.0 Federal scientist man-years were devoted to costs and returns work involving tobacco.

PROGRAM OF STATE EXPERIMENT STATIONS

The State Experiment Stations devoted 1.6 scientist man-years to research on tobacco farm costs and returns.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

Costs and Returns by Major Types of Farms

In cooperation with the Kentucky and Tennessee Experiment Stations, estimates of costs and returns for 2 types of farms in the Kentucky-Tennessee Pennyroyal Area were completed. Results of these studies show that substantial gains have been made in production and net farm income per farm since the mid-1950's. Net farm income for 1964-66 averaged 64 percent higher than in 1954-56 on tobacco-beef farms; on tobacco-dairy farms, income was 60 percent above the 1954-56 average. Net farm production advanced 44 percent on tobacco-beef farms and 74 percent on tobacco-dairy farms during this period.

PUBLICATIONS--USDA AND COOPERATIVE PROGRAM

Shugars, O. K., Bondurant, J. H., and Keller, L. H. 1967. Costs and returns, commerical tobacco-livestock farms, Pennyroyal area, Kentucky-Tennessee, 1965. Ky. Agr. Expt. Sta. Misc. Pub. 344. 8 pp.

Shugars, O. K., and Tippett, D. E. 1967. Costs and returns, commercial tobacco farms, Coastal Plain, North Carolina, 1966. FCR-46. 8 pp.

Shugars, O. K., Bondurant, J. H., Keller, L. H., and Tippett, D. E. 1967. Costs and returns, commercial tobacco-livestock farms, Bluegrass area, Kentucky and Pennyroyal area, Kentucky-Tennessee, 1966. FCR-49. 12 pp.

ECONOMIC AND STATISTICAL ANALYSIS

Economic and Statistical Analysis Division, ERS

Problem. Because supply and demand factors for tobacco and tobacco products are changing continuously, these factors must be regularly appraised and these appraisals disseminated to farmers, the trade, and other interested persons. The typical tobacco farmer cannot afford to collect and analyze the statistical and economic information that vitally affects his economic position. Economic facts and analyses must be provided on supplies, prices, production and consumption of tobacco and tobacco products, and the export-import trade. Proposals to modify existing tobacco programs must be analyzed to assist the evaluations of alternatives by administrators and Congress. In addition to the usual economic variables, analyses have to take into consideration the health-related aspects as they may pertain to consumption of tobacco products and utilization of tobacco leaf.

USDA AND COOPERATIVE PROGRAM

The program includes a continuous appraisal of the current and prospective economic situation of tobacco. These appraisals, together with developments of interest to the industry and results of special studies, are published four to six times a year in the various commodity Situation reports, with brief resumes in the quarterly Demand and Price Situation, and when appropriate in monthly issues of the Farm Index and the Agricultural Outlook Digest. Pertinent information is also presented at the Annual Outlook Conference, and at meetings with industry groups. Special analyses are prepared from time to time on the probable effect of proposed programs on the supply, price, and utilization of tobacco.

The program of basic research into the factors affecting prices, supply, and consumption of principal agricultural commodities is concerned with four broad areas: (1) Measurement of consumer response to price, income, and other factors; (2) measurement of producer response to price and other factors; (3) measurement of the effect of supply and demand factors on prices to farmers and to consumers; and (4) improvement of statistical techniques for measuring agricultural economic relationships in agriculture.

Changes in emphasis are made from time to time to utilize effectively the professional skills available and to adjust to work having the highest priority. The research on tobacco is related to economic effects of technological changes including information relating to health on supply, demand, utilization, and price of leaf tobacco.

A total of 2.0 scientist man-years were devoted to these programs in 1967.

PROGRAM OF STATE EXPERIMENT STATIONS

The State Experiment Stations devoted 0.6 scientist man-years to research in this area.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Commodity Situation and Outlook Analysis

During the past year attention was given to the problem of tobacco exports, including probable effect of alternative export programs. This work provided guidance for policy decisions in connection with the tobacco export payment program announced in June 1966. The Rhodesian situation was closely followed because of its importance to the world tobacco trade. Analyses were made of the probable effects of the acreage-poundage program on burley tobacco supplies and yields per acre in the event this program were to be approved by growers. Although 57 percent of the burley growers voting last February favored adoption of the acreage-poundage program, the law requires a favorable vote of more than two-thirds if such a program is to go into effect. Cigarette consumption in selected States was studied to discern whether different trends existed, and to appraise the effects of increases in State cigarette tax rates. In June 1966, cigarette prices to consumers were 11 percent above 2 years earlier. About four-fifths of the rise was due to increases in State cigarette taxes. The national pattern of tobacco products consumption was watched closely to detect differences in direction and rates of change.

B. Supply, Demand and Price

Continuing analysis was made of trends in utilization of tobacco as affected by recent technological changes, and their impact on growers. Review was made of data made available on a confidential basis from two surveys conducted by the Public Health Service, relating to tobacco use, smoking and health, and consumer attitudes. Arrangements have been made for consultation with PHS in connection with future surveys. Additional analysis was made of alternative methods of supply adjustment. Also, per acre yields resulting from the flue-cured tobacco acreage-poundage program were studied, and possible methods of adjusting yields established for individual farms were explored.

PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS

Conover, A. G. and Sackrin, S. M. Tobacco Situation. Published quarterly. ERS, USDA, Washington, D.C.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1968 301-752 (ARS-136)